

# MAIN CURRENTS IN MODERN THOUGHT

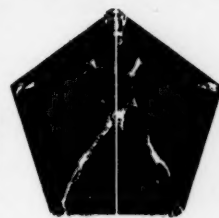
A monthly service that brings together contemporary data in all fields, as these issue from laboratories, studios, class-rooms, observatories and wherever man pursues the eternally intriguing and beautiful mysteries of Nature

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"Ah, but a man's reach should exceed his grasp, or what's a heaven for?"—BROWNING



## MATTER, LIFE AND CONSCIOUSNESS

## Editorial Summary

**M**AIN CURRENTS IN MODERN THOUGHT is a monthly journal recording contemporary developments significant to thought. By proper organisation, thousands of source-journals are drawn upon. In making decisions as to what may be of importance the source-readers are aided by certain agreed-upon standards which are revised from time to time. Selected material is edited, and important discussion is guided by an editorial advisory board.

It will be evident that the success of the service thus rendered depends in part upon the competence and carefulness of the source-readers and in part on the editorial work done upon the material. As it depends also in large part upon the nature of the standards by which the source-readers are guided, it is proper to publish an identification of our interests for general information. The following, in extremely compressed form, are some of the criteria in use by our source-readers to-day. They are intended only to suggest how the great domains of inquiry are held together, but do not necessarily represent what each source-reader may hold important within his own field. In other words, what follows is a minimum account, is tentative, and touches on the main stream of current interests. It is intended to be not final but provocative.

IN THE PHYSICAL SCIENCES it is certain that a great shift in outlook has occurred as a result of electronic and astrophysical studies and the mathematical developments attending them. We now know of a new world, whose properties are most in evidence at its two extremes: in the macrocosm of stellar and nebular systems, and in the microcosm of electronic and nuclear physics. But are we to fancy that our terrestrial world, the familiar world between macrocosm and microcosm, is without these same new-world properties? Surely, its conspicuous features at least — and among them life and consciousness, certainly — can be interpreted afresh by the same token with which matter, taken as energy, has been reevaluated.

What has been done to our long-held ideas by Einstein, Minkowski and others is so profoundly important that any appropriate figures of speech that we might use to describe it would sound simply lyrical or hysterical. All the same, a phrase such as a *convulsion* or *revolution in thought* does not exaggerate. It does perhaps mislead, because the more nearly correct picture of what has happened is that of an irresistible flood stealing up to float away our familiar landmarks.

It is difficult to be patient with people who say that they are "not interested in these things which have nothing to do with my daily life." If it were impossible to comprehend the new departure in thought, or if it were a merely temporary one, their indifference could perhaps be justified. But what has happened is essentially simple — irrevocable and sweeping though it be — so simple that there is no excuse for mistaking it, so simple that when it is said it sounds empty!

And what is this, then, that has happened?

The physicists have shewn us that time and space are not separate but are one continuous and homogeneous system: a continuum. This was the departure. Now the great mystery of time was about to deliver up some secrets. Since time was henceforth to be known to be one with space, it could be measured as space is measured. And is it not space we measure when we plan for a person's physical needs, for cities, for society; when we design machines, plan houses, and survey land? But until we could measure time in this way, it ever remained our enemy. Time had been the eternal flux of shadows at which man grasped in vain. Time-conscious man was then a lonely vagrant in the flux because he uncomprehendingly, yet consciously, suffered from it. If like the beast he were unselfconscious, the fleetingness of time and of his life would then not sadden him.

But now that time was to be known and dealt with as one with space in space-time, it was no longer to be measured by the motion of a planet or the movement of a clock, as "a dark backward and abyss"; it became a part of geometry — the new geometry, of space-time. And since man is a geometer, his self-conscious powers were to lift him to his essential identity with the grand geometry of nature.

We shall, of course, continue to live brief lives; but our earthly living can be conducted, conceptually and nobly, from the elevation of a higher dimension: We have entered a new world.

This new world of Riemannian space-time is, then, as revolutionary to thought to-day as round-earth doctrine was to the flat-earth era of thought. And just as those explorers who were confident of round-earth truth found new continents, so, surely, taking to-day's new-world concepts as real and dependable, we may confidently examine our familiar world for evidence that it too may be more truly envisioned as within this space-time matrix of the nebular and electronic cosmos. What

this matrix may finally prove to be, as mathematicians work upon it as four and even higher dimensions, obviously cannot be forecast precisely. How its properties, both speculative and as seen in Nature, appear to the physicist to-day was discussed in *MAIN CURRENTS*, November 1942. At any rate we may say that the world of ordinary experience is to the space-time matrix as a world of flat shadows (like Plato's cave) is to a world of light.

The two modes in which space-time is currently viewed are referred to in language as exact as brevity allows: (1) Space-time may be thought of as a continuum whose most prominent characteristic is that matter (or energy) is present in it: any other characteristics that it may have are thought of as depending from this fact. This is called the physical world of space-time. Obviously it is this world alone which is perceived through physical senses. (2) But the mind, on its own account, perceives another space-time world, not physical, yet real in the sense that basic mental properties of our minds (such as axioms) concern pure space-time properties; and the existence of this ideal world is then found by observation to be indicated by the behaviour of the said matter-energy content. This mental space-time world is coherent. On the other hand, the physical space-time world is not coherent in the case of the small quantum cell (and there only internally), but this does not make this (physical space-time) world totally incoherent and unpredictable, nor mean that it is a world of mere probability: on the contrary, it is reasonable and dependable; and physical coherence cannot be a composite of incoherent probabilities. In other words, the great conglomerations of matter, in greatest degree (and most complexly) those which we know as the bodies of living organisms, behave conformally to ideal space-time properties. In the succeeding paragraphs, then, the term *space-time* refers to the ideal world. A beautiful exposition of the relation of the physical to the ideal world is given by Dr. Gustaf Strömberg (see *The Coherent World-Matrix*, in this issue).

The theorems of modern physics stand on a secure footing all their own. Yet in a philosophical sense they imply a re-union of the best thought of antiquity, represented by Plato and Shankaracharya, with the best thought of our times, represented by Einstein, Whitehead, and others. Thus the new developments in physics can evidently lead to an essential union of world culture. They have demanded a new attitude in thought. In order to typify this attitude, we may say for example that modern mathematical fine-world physics and astrophysics are a new species of transcendental realism: the universe is not taken as a machine but as a mind. Now, if the universe is somehow a mind, the need for a good science of psychology, adequate to these implications of modern physics, is obviously an important one.

IN BIOLOGY, in all its aspects, a profound stirring is evident. The recent reissuance of Sir D'Arcy Thompson's work *On Growth and Form* emphasizes that vitalisms, and entelechies, and other such premature attempts to liberate certain phenomena of biology from the domination of physical and chemical laws, are being relinquished. In this work, mathematics is applied to biology,

but very little is employed of the knowledge, lately formulated in physics and chemistry, to which we have referred as the world of space-time. Future studies in biology must take account of space-time properties; so in this field we may reasonably look forward to remarkable developments and simplifications in such terms. Already in orthogenesis such an extension is foreshadowed by certain critical discoveries which have been made in the borderland which lies between crystals, whose beautifully symmetrical space-properties are well known, and certain definite biological entities whose "time-properties," such as cyclism and related phenomena, are still inadequately understood. Many new developments surrounding the question of viruses, colloids, polymer molecules, and crystal-products of protoplasmic cells are concerned. But the process will not end with fine-world discoveries; so, as we have said, we may confidently anticipate simplifications of classification in biology, and much rationalising of morphology of higher plants and animals in extended future terms of the same transcendental realism.

We see tendencies in this direction in the concept of the Individuation Field. Substances called organisers and evocators are known to appear in embryos in exactly the right quantities needed to effect the growth of the creature to maturity. Here we have a precise correlation, both qualitative and quantitative, between an electromagnetic entity (the evocator) and a living creature. The individuation field is not to be wrenched from the physical context. Yet neither is the opposite assumption to be made, to wit, that no new properties of space-time are to be found by studies of the individuation field observed in the creature. The new concept implies that the individuation field is the private space-time (so to speak) of that creature. Its biological and its psychological properties must be conceived to root in some space-time properties not yet elucidated in biology to date. Indeed, many properties described ideally by pure geometries of space-time, and even of higher multi-dimensions, may confidently be expected to be found applicable to these and other biological data.

FOR PSYCHOLOGY, in its several forms, the term *self-consciousness* is taken by our source-readers naively as that special feature of the human mind which sets it off sharply from the animal mind. But just as animal form and behaviour can be increasingly successfully described as part of the space-time matrix, so also we must expect that the physiology and psychology of man will be examined afresh in like terms. Therefore, again, just as the individuation field in biology shows strange properties, not yet explicable in physical terms — it is always accompanied by psyche — though they may some day be described in terms of pure mathematics, so also may new pure terms and fresh developments be expected in the psychology of man, even before his relation to the space-time matrix is properly appreciated in the field of science. It is safe to say that much quite fresh experimentation needs to be done in forward fields to obtain even a good factual footing in the case of psychology.

Enough data has already accumulated, however, to suggest that the distinction which Jung made between a lower psyche (*anima*) and a higher psyche (*animus*) is

both good and important. We may believe that the evolutionary event, emergence of self-consciousness, in man, is accompanied or followed by the growth of things mental at a higher level than that of the lower (Freudian) psyche, with its herd-, ego- and sexuophysical complexes. Here (following Jung) we may aptly speak of an autonomic field, in which consciousness operates, much as we speak of an individuation field for growing organisms in biology. We would not suggest the use of this term firmly as yet, the proposal being merely conjectural. But, just as the evocator, the individuation field, the organism and its psyche are together a single whole at a lower mind stage in the animal kingdom, so also we may tentatively think of self-consciousness, and, associated therewith, the forebrain, and an autonomic field, in man. Crucial to this concept is the work that has been done on cerebral and nerve-action currents, showing differences when consciousness is and is not active. However, because of the arrested state of psychological science, due in part to world conditions which have interrupted new movements in gestalt and parapsychology, a tentative and, also, a generous attitude is to be maintained toward psychophysiology. Much emphasis may be placed by our source-readers therefore upon the concepts of great psychological philosophers such as Leibnitz and Bergson (to cite European names) and Laotse, Patañjali and Siddharta Gautama (to mention Eastern personages), pending further modern developments.

Since so much turns on this point, the character of consciousness, it is necessary to develop the argument at some length.

In the animal kingdom, life and mind are inseparably bound together. At higher levels of evolution, the psyche is obviously complex and important, but ability to learn is observed to exist in quite low organisms. As we descend into the plant world we find that intelligence fades away and mere adaptability begins. It has never been possible to draw a sharp line of distinction between animal and plant response; and the protoplasm is also there as a link to keep these kingdoms close together as the common territory of life. There is, however, a dual functional difference between animals and plants, which, if properly evaluated, more than offsets the resemblances in their protoplasms and cells. The plant engages in what the chemist would call synthetic chemistry. It puts together relatively simple chemical materials and makes up complex molecules, employing the sun's energy to convert air, water and earth into proteins, sugars and starches. The truly synthetic and step-up nature of this process is evident in soilless culture, wherein only inorganic chemicals are supplied from a liquid (with its solutes) and from the air. The animal, however, engages in exactly the reverse kind of chemistry, namely, analytic. He takes in the complex molecules of starch, protein and sugar originally made by the plants (which he eats), and converts them (i.e., breaks them down) into energy and work. Indeed, as we know, some animals can and do live their whole lives cut off from sunlight in sea-depths and at very low temperatures and high pressures. Accompanying this metabolic functional difference between plants and animals is its important psychic correlate.

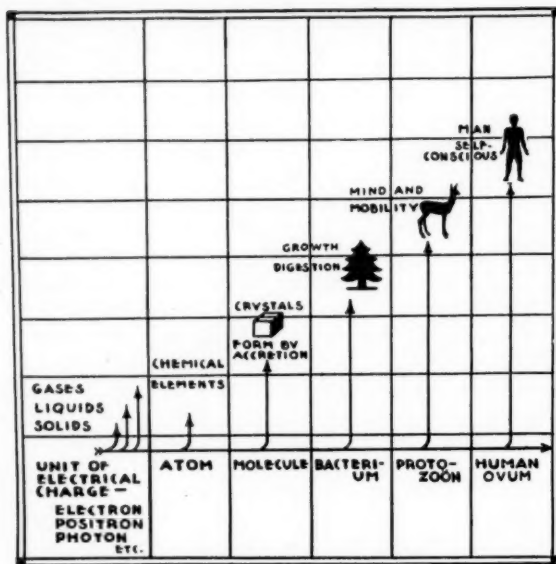
The animal is able to break down a new and often complex experience situation, as we may see in Köhler's well-known experiments with apes, who had to fit sticks together in order to reach bananas. It is significant that this analysis of a complex situation which occurs in the animal suggests a reciprocal relation to the analytical chemical metabolism. Not being self-conscious, the animal does not, of course, first objectify the situation, as man can. On the contrary, the animal's analysis is for the most part as direct and automatic as his digestive process is. The plant, in contrast, lives a psychic life (if we may use such a term in this connection) in which no analysis of a situation is to be observed. Growth of roots downward and of stems upward is determined by internal and external energy and fields of space; for the seedling the only (as yet recognised) force is that of gravity: if we let a seedling grow in a container placed on a machine which rotates it, so that the force of gravitation is centrifugal, we find that the roots grow in the direction of the artificially induced gravitation, and not downwards. In maturing plants the energy of sunlight comes into play. The plant then displays phenomena of response, and if it has any psychic life we must conceive this to be rudimentary feeling. Now for psychic life the animal has sensations and emotions, but most of this order of psychic life is confined to *conditioned reflexes* in his organism, a state of affairs already found to be standard in plants. We cannot escape the conclusion that this short-circuiting of the animal's emotional and sensational life into conditioned reflexes makes room, so to speak, for the new order of response: analysis and mind; for a differentiation appears early in the embryo's development as a polarity of the vegetal and the animal cell complexes, and these give rise to appropriate structures which are the seat of the vegetative and animal functions.

To-day our knowledge of plant and animal differential relationships has moved a long way from the simple concept of a mutual oxygen-carbondioxide cycle. Nevertheless, the decisive significance of the great kingdom mutations has not been widely enough recognised. We now perceive that mutations are each correlative to definite psychic evolutionary forward steps. Since these advances are connected with definite epochs of time (evolution), as we shall see presently, it follows that they are also connected with time as a component of space-time. Time — ideal time — may therefore be conceived to have properties which psyche reveals, to the same degree and by the same token that physical forms reveal space properties. This is a point of supreme importance in the connection which it has with the evolutionary psychology of man, because of man's richer space-time frame of reference. We need but think of man's creative arts of music and architecture, let us say, to see that the soul of man resides in a far superior and richer region of the matrix.

To return to an earlier portion of our theme: the boundaries between crystal and plant, hitherto sharp, have lately become blurred by the discovery of living creatures, molecular of size and with affinities to the crystals: the viruses. Consequent on these developments, and pursuant also upon a more penetrating psychology, the psyche aspect of the kingdoms has grown increasingly important. The question has arisen: Has the evo-



lution of psyche been a smooth continuous procedure, or has it proceeded by stages of mutation, particularly at the point where man made his appearance?



Evolution and space-time scheme referred to in the text. Homogeneity of space-time is understood; its limitation to a fourth dimension, however, is not implied.

The horizontal series begins with relatively simple atom-spins, and passes through crystal-lattice properties to increasingly subtly-revealed space-time properties. They are all limited to fine-world domains of the single cell in each kingdom. This is not principally a time-series, since crystal, plant and animal cells made their appearance in the Proterozoic Era nearly simultaneously.

The vertical scale represents properties due to time, especially in its reference to geologic epochs, and hence an "evolution" of material environment.

Thus the resultant slope of the figures represents familiar terrestrial evolutionary development of forms with parallel evolution of psyche.

The situation in its broad outlines may be represented in a diagram in which biochemical complexity is indicated as increasing in the direction of the horizontal axis, or abscissa, and mind complexity increasing along the vertical axis, or ordinate. It is obvious that the vertical direction has a close analogical connection with the time-element in evolution, for the kingdoms of the mineral, the plant, the animal, and man are the specialties each of a vast geologic epoch. Each such epoch is set off from the one before and the one after by what in geology is called a Revolution. The broad facts of this whole set of connections are to be found, beautifully compiled, in *Geologic History at a Glance*, by L. W. Richards & G. L. Richards, Jr. (Stanford University Press). They are, no doubt, well known, but we will summarise them here:

In the Archæan, or earliest, period came the vast Laurentian (and later the Killarney) Revolution, the greatest unconformity and erosion era in the earth's history. This is properly the Age of Crystals, for then for the first time the molten minerals settled down upon the fourteen varieties of space-lattice which govern crystal-classes. Then came the Proterozoic and Palæozoic Eras, in which the conspicuous feature was the appearance of life in the waters, and the conquest of the land in a great climax by the spore-plants of the Devonian and Carboniferous ages. Animal life was limited for most of this time to the waters, which it shared with plants. The accent, however, was on plant life, and so

we may call it the Plant Age. Then came the Appalachian Revolution, to usher in the age of land animals, broken into two parts by the Laramide Revolution, with great reptiles before and mammals after it. Now the opulent feature of life was animal diversity, size and distribution. This third or Animal Age was ended by the Cascadian Revolution, which marked off the beginning of the present, or fourth, epoch. The important point is that there has been a conspicuous abatement of new species-formation at this point. In fact Frieling flatly declares: "Since the origin of man, in the Tertiary, the creation of species has ceased; subsequent alterations are of a subspecific character." (See MAIN CURRENTS, September 1941, page 7). This event, concomitant with the appearance of man, has far-reaching meaning. If crystal, plant and animal have come each in turn in this order of sequence to form and to possess the continents, and if with man's appearance the emergence of new species in those three preceding kingdoms slackens or even ceases, then, and in respect of this arresting fact, the (specific) uniqueness of Man as a kingdom on his own account is unmistakably implied. The vast panorama of geological time and of life epochs together with the systematic evolution of psyche is one ordered whole. And so it follows that this is the Age of Man — in a very important new sense. We begin to perceive an over-all order in the time part of the space-time world. This time-domain is evidently related to the psychic element, since the time-sequence of forms on earth is clearly and systematically related to a sequence of psychological evolution-developments, culminating in (human) self-consciousness.

To-day, physical evolution is not conceived as moving steadily along the slope of the line of creatures. But how about evolution of psyche? Does it proceed by graduation? This question cannot be answered at this point of the argument, for all that we know is that the passage of time is accompanied by the operation of a process in which organisms exhibit more and more intricate psychic resource.

Many of the differences displayed by the simple bases of each kingdom (along the horizontal axis) are detectable by chemical analysis and amenable to mathematical description. (Example: the cellulose in the cell wall of the plant is made up in part of crystals which have been manufactured in the protoplasm and move out to the surface to form the wall; while in the animal, the boundary of cells usually is provided by surface tension.) The same may be said of the details of cell arrangement and tissues of the complex creature. But when we come to describe the creature as a whole (gestalten) we find the resources of chemical and physical sciences steeply inadequate, and here they are forced to leave the task of description to the mathematician. And, on account of the time-like character of the vertical axis, the mathematics which he must use is, necessarily, that of space-time: more-than-three-dimensional. The retarded state of description of Nature to-day is due to the limitedness with which the properties of the fourth dimension are applied to the problems of the non-physical sciences.

The horizontal series in the above diagram deserves close scrutiny. The human ovum in many ways resembles

other ova among the thousands of animal cells, especially mammalian ova. Yet when we consider the psychological out-workings which eventuate from the maturing of a human ovum we are surely compelled by the exigencies of simple intellectual honesty to say that the chemical and mitotic (cell reproduction) resemblances and differences are entirely misleading if taken by themselves as the sole explanation of later developments. Hopes of explaining human maturing in terms of fine-world chemistry and physics are simply fatuous or blind, for obvious reasons. Human psychic out-workings belong to an order of events entirely different from animal behaviour because in human beings the self-conscious and volitional forms of architectural planning, recollection, intelligent language and the rest, are the tokens *par excellence* of "high-level responses" (Sir Henry Head), superior activities the appearance of which is made possible only by appropriate development of the human form and upon full association with growing and adult humans by whom these cultural powers are already being exercised. The case of the Wolf-Girl, noted under *Recent Items*, ratifies this observation.

We have, from that case, authority to ask the question: Would a child be human if, even though brought up in a warm house, well fed, clothed and attended, it were denied fun, love, impulsive action, music, colour, surprises? Obviously not. What, then, is at work? To-day we can answer only that there may be something we could call a psychic climate, in which ordinary humans live. We know virtually nothing of the properties of this imponderable background of life. But we may properly watch for evidences of it. There was a time, for example, when we did not know that sea air and fresh-water lake atmospheres were oppositely electrically charged, yet nevertheless physicians prescribed the two environments differently for different cases, with successful results. Nowadays we know that sea air lowers and the other heightens the acid-content of the blood (pH), and that the whole sympathetic nervous system is affected by it. As to psychic climate, we know almost nothing of it: only that something of that sort seems to exist.

Let those who resist the idea, that the space-time framework of life operates constantly upon the growing organism and not in its fine-world beginnings only, ponder certain facts: "The egg-cell itself," Dr. H. J. Muller tells us (*Out of the Night: a biologist's view of the future*, pp. 19-20) "is so tiny that if we could collect all the human eggs now existing which are going to form the next generation of mankind — two thousand millions in number — we could pack them in a one-gallon pitcher . . . The hereditary substances of both eggs and sperm together would form just one tablet the size of an aspirin tablet [if the nutrient material be omitted as unessential] . . . Surely, then, this cell-substance is incomparably more intricate as well as more portentous than anything on this earth." If we try to explain according to old ideas how the future generation's 876,000,000,000,000 man-&-woman-hours of achievement, frustration and pain can arise from this "aspirin tablet", we acquire a philosophical headache of considerable magnitude. But if we admit the guidance of space-time subtle properties in the ovum, and the continuance of this framework as a trading-ground of the

whole growing organism both physical and psychic, we can at least hope for understanding. The current annual report of the Carnegie Institution of Washington contains accounts of the earliest known normal fertilised human embryos,  $7\frac{1}{2}$  and  $9\frac{1}{2}$  days old. The ectoderm and endoderm are not as yet unrolled in the earlier, and already unrolled in the later. At  $18\frac{1}{2}$  days the tissues which will give rise to the head are identifiable. What pattern is at work in this highly specific development? Must we not suppose that there are many properties of the electromagnetic field at work here of which as yet we have little suspicion, and that many of them are so low in the charge-scale — far below the electron-volt — as to be virtually properties of time-space itself?

We start on a long course of thought when we concede in modern physics that the description of atomic and molecular activity is possible only by drawing on a fourth dimension. The vertical direction in the above diagram must be taken to mean quite possibly a dimensional, as well as a psychological, enlargement. We are not entitled to assume, however, that this enlargement ends by the step from three to four dimensions. We have shewn man, above, as part of a natural sequence, but he is in fact marked off from the preceding kingdoms by self-consciousness. Nothing like self-consciousness is found in Nature, save in man, where it is his special mark. Domestic animals shew no interest in their reflections in a mirror as referring to themselves. Therefore, though we put man in line in the evolutionary series in the diagram, it may come to be agreed that he marks psychologically the transition from one kind of hyper-space to another of still greater dimensional resource. Perhaps the reason why he can deal with the mathematics of the fourth dimension at all is because as a consciousness he is lodged in a dimension higher still. This possibility also gives room for the difference between the anima and the animus, to which we have referred. We make this point only in order that it may be kept in view, as experimental subject-matter comes forward in the field of psychology.

Now for a rounding-out of our argument we need but one more block of evidence. The argument implies that man is a fresh mutation in a psychological sense. It admits the assumption that the Platonic soul (the Good, the Beautiful and the True — our *autonomic field*) is as much a reality as is the Freudian psyche we share with animals (selfish, vain and passionate, in man). Now social life in the animal kingdom describes itself in terms of their bodies, their psyches and their environment, and this their social life (ecology) is to-day known to be a symbiosis or mutuality, the price being paid in death, by zoöphagy. If man is not a fresh mutation in the inner or psychological sense, then it follows that predatory war is good, fascism is right, and cannibalism is desirable. But if man is a grand mutation, then there must be evidence somewhere that a social individuation, or autonomic, field is operating at the level of the animus (soul) between individual humans: there must be laws of mutuality in operation at this superior level in the space-time matrix.

In our March issue we shall supply what is the only objective evidence, known to us, of definite geometric space-time forces at work in a group of people at the

moral level and hinging upon ethical values. This item will render complete the summary of psychological standards compiled editorially to show the considerations by which our source-readers are guided in selecting source-materials, and it will allow us to turn our attention to the sociological field without losing sight of the

basic space-time matrix principles by which we have lighted our way throughout. It allows us also to bring the valid principles underlying the fine-arts and rational religion into play, so that (still within the same matrix) we may close our brief summary of standards on a keynote of social meaning.  
F.K.

## ON GROWTH AND FORM

## Book Review

**N**EARLY TWENTY-FIVE YEARS have passed since D'Arcy Wentworth Thompson first launched his remarkable book *On Growth and Form* upon the high seas of the thinking world. Since then there have been repeated demands (in *Nature* and elsewhere) for more of such exact studies of the broader principles running under evolution; and much reading of this one has reduced public-library copies of the volume to tatters. The original edition has long been exhausted. Now, at last, Sir D'Arcy has given a revised and much enlarged version of his great work to a grateful world. Although nothing of its kind has appeared in the meanwhile, the thesis has grown more, and not less, important; and so our conviction has increased that it is a truly indispensable source-book for the philosopher.

Treatment of the subject of living natural order is limited severely to the terms of Newtonian physics: "Since this book was written, some five and twenty years ago," Sir D'Arcy himself writes in an early passage, "certain great physico-mathematical concepts have greatly changed. Newtonian mechanics and Newtonian concepts of space and time are found unsuitable, even untenable or invalid, for the all but infinitely great and the all but infinitely small. The very idea of physical causation is said to be illusory, and the physics of the atom and the electron, and of the quantum theory, are to be elucidated by the laws of probability rather than by the concept of causation and its effects. But the orders of magnitude, whether of space or time, within which these new concepts become useful, or hold true, lie far away. We distinguish, and can never help distinguishing, between the things which are of our own scale and order, to which our minds are accustomed and our senses attuned, and those remote phenomena which ordinary standards fail to measure, in regions where (as Robert Louis Stevenson said) there is no habitable city for the mind of man. It is no wonder if new methods, new laws, new words, new modes of thought are needed when we make bold to contemplate a Universe within which all Newton's is but a speck. But the world of the living, wide as it may be, is bounded by a familiar horizon within which our thoughts and senses are at home, our scales of time and magnitude suffice, and the Natural Philosophy of Newton and Galileo rests secure."

As to this we may well have reservations. But the studies are factual, and their great value is not diminished by opinion. We shall allow ourselves, however, an occasional reference to the larger world of Einstein and Minkowski, in what follows.

*On Growth and Form* is an inspired and inspiring collection of source-data about the shaping and the

shapes of organisms, discussed in terms of common and really very simple mathematical principles. The author is concerned more with design than with purpose. The psychological import of his subjects is scarcely touched upon. But he has a lively awareness of these urgent matters and writes in that simple and generous style which is natural to the man of wide knowledge. And he is the antithesis of a mechanist: "In short, he is deeply reluctant to compare the living with the dead, or to explain by geometry or by mechanics the things which have their part in the mystery of life" (p. 3). He puts the question of values away: "How it is that the soul informs the body, physical science teaches me nothing; and that living matter influences and is influenced by mind is a mystery without a clue. Consciousness is not explained to my comprehension by all the nerve-paths and neurones of the physiologist; nor do I ask of physics how goodness shines in one man's face, and evil betrays itself in another. But of the construction and growth and working of the body, as of all else that is of our earth earthy, physical science is, in my humble opinion, our only teacher and guide." (Page 13. Numbers in parentheses will refer to pages.)

One important aim of this fruitful and patient inquiry is to make clear that "there is an essential difference in kind between the phenomena of form in the larger and the smaller organisms." (57) The linear dimensions of objects and creatures defines the scope of the work. Above it lies the astrophysical realm, where the writ of Minkowski runs; below it begins the atomic dream-world of Bohr. We cite the table of sizes from page 66.

"Life has a range of magnitude narrow indeed compared to that with which physical science deals; but it is wide enough to include three such discrepant conditions as those in which a man, an insect and a bacillus have their being . . . Man is ruled by gravitation, and rests on mother earth. A water-beetle finds the surface of a pool a matter of life and death, a perilous entanglement or an indispensable support. In a third world, where the bacillus lives, gravitation is forgotten, and the viscosity of the liquid, the resistance defined by Stokes's law, the molecular shocks of the Brownian movement, doubtless also the electric charges of the ionised medium, make up the physical environment and have their potent and immediate influence on the organism. The predominant factors are no longer those of our scale; we have come to the edge of a world of which we have experience, and where all our preconceptions must be recast." (77) ". . . Some form or degree of spherical symmetry becomes the rule in the small world of the protozoön . . ." (68), as it does in the larger one of



earth and star. Between these life looks out on both sides of that narrow range "where gravity and surface-tension become comparable forces, nicely balanced with one another." (67)

That all these worlds are but appearances and lie like electronic mists over a deeper reality, the reader perceives further along: "Time is always implicit . . . but Time as a dimension can only be substituted for one of the three dimensions already there." (79) With these words we start upon the long passage in which rate of growth is to occupy our minds for two hundred pages. Here Sir D'Arcy has laid down those substantial facts which thinkers of to-morrow, who will treat biologic time as part of the homogeneous real space-time and not as a substitution in a map, will prize for their clarity and reach. In sum, ". . . organic form itself is found, mathematically speaking, to be a function of time." (79)

There are graphic passages through which we are driven to picture man entering into the scene of the physical world through an aperture (the ovum), as minute as the pin-hole of a pin-hole camera, through which play forces as little energy-charged as rays of light, yet effectual enough to assemble the sensitive mother-materials. Embryos a week old would be so small that seven of them would be required to cover the punctuation-mark which closes this sentence. After the floating foetal stage come birth and the long struggle between energies of growth and energies of the solar system, "the unequal contest between our bodily powers and the unchanging force of gravity, which draws us down when we would fain rise up; we strive against it all our days, in every movement of our limbs, in every

beat of our hearts. Gravity makes a difference to a man's height, and no slight one, between morning and evening; it leaves its marks in sagging wrinkles, drooping mouths and hanging breasts; it is the indomitable force which defeats us in the end, which lays us on our death-bed and lowers us to the grave." (93) Truly, as we judge from Sir D'Arcy's facts, though it does not follow from his argument, man is an intruder from another world. Life implies peculiar properties of space-time that can show themselves in this world only after ages have prepared those delicate balances among the many forces of space-time and energy which allow these subtle symmetries to reveal themselves.

The relatively few simple styles of curves, "a straight line, a parabola, or hyperbola, an exponential or a logarithmic curve (like  $x = ay^b$ ), a sine-curve or a sinusoid, damped or no, suffice for a wide range of phenomena; we merely modify our scale, and change the names of our coördinates. The curves we mostly use, other than the Gaussian curve, are *time-diagrams*." (138-9) Here the author treads on the very verge of the homogeneous space-time world, rich with bizarre, non-Euclidean properties such as (let us call them) conic sections at infinity, and endowed with strange resources such as of simple knots that can be tied (some wizards say!) in closed circles, or such as one-side surfaces and all the other curiosa of that world so dream-like yet so signal in its possibilities for an explanation of life.

The author has concern for the compounding of organisms in time (144), the process whereby living things reproduce, in astronomically large quantities, that which is doomed to perish ere it has lived what might have been its life, but which in its incredible totality outfaces the starry systems — Life, which molds Matter to its own ends on a scale that dwarfs the thousands of millions of galactic systems in the sky. "A fungus is growing on an oaktree — it sheds more spores in a night than the tree drops acorns in a hundred years" (144) — immortal life using no less immortal matter — "and Bose tells us that plant-growth proceeds by tiny and perfectly rhythmical pulsations, at intervals of a few seconds of time." (171) Quanta of growth are the heart-beats of a crocus in the springtime snow. "For the main features which appear to be common to all curves of growth we may hope to have, some day, a simple explanation." (281) That day is surely close at hand, and the explanation is possibly to be found in the properties of space-time, of which we have, in our Editorial Summary, already spoken. And it will be then the solid value of so unparalleled, so close and so warmly sympathetic a study of the simple facts as *On Growth and Form* gives us, will be fully recognised.

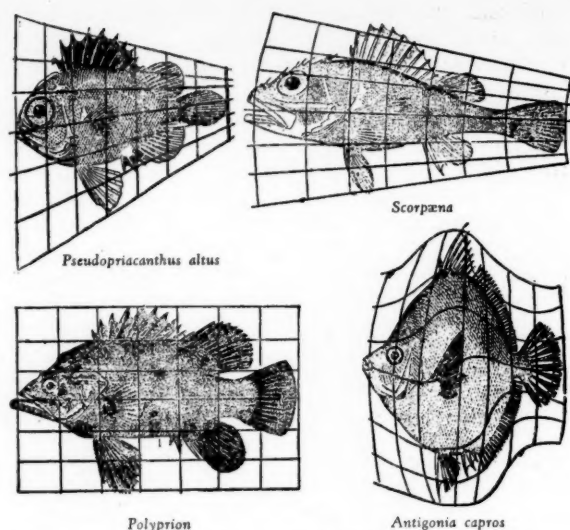
The central portions of the present edition are devoted to internal form, and to the structure of the cell. Well displayed is the monster world of the chromosomes, where stasis and kinesis as titans strive, and leave their record in a grammar of living geometry. From here we pass to the forms of cells, and come upon the physical and biological laws at work in the crystal, the bacterium, the protozoön and the ovum and see the structural characteristic which allows us to relate organisms by descent. In the cell itself, and in the first aggregations of cells, "specific characters are few and simple,

	m.		
(10,000 km.)	$10^7$	A quadrant of the earth's circumference	
(1000 km.)	$10^6$	Orkney to Land's End	
	$10^5$		
	$10^4$	Mount Everest	
(km.)	$10^3$		
	$10^2$	Giant trees: Sequoia	
		Large whale	
	$10^1$	Basking shark	
		Elephant; ostrich; man	
(metre)	$10^0$		
		Dog; rat; eagle	
	$10^{-1}$		
		Small birds and mammals; large insects	
(cm.)	$10^{-2}$		
		Small insects; minute fish	
(mm.)	$10^{-3}$		
		Minute insects	
	$10^{-4}$	} Cells	
			Protozoa; pollen-grains
	$10^{-5}$		Large bacteria; human blood-corpuscles
(micron. $\mu$ )	$10^{-6}$		
		Minute bacteria	
	$10^{-7}$		
		Limit of microscopic vision	
	$10^{-8}$	} Colloid particles	
			Viruses, or filter-passers
			Giant albuminoids, casein, etc.
		Starch-molecule	
(m $\mu$ )	$10^{-9}$		
		Water-molecule	
(Ångström unit)	$10^{-10}$		

... largely referable to the direct action of a physical force," (413) — which is to say that here, in the bases of life in all kingdoms, environment and life meet as equals, whereas in highly compound organisms it is the long-range time-operations which govern: and here, again, is our faithful companion psyche, hovering outside Sir D'Arcy's theme, but quietly tending his facts. When we operate the long-fibred muscles of our own organism by volition, it is the psyche which (doubtless, in the creative arts, at a high level) is at work. Psyche is also a concomitant, broadly speaking, (with other factors) of muscle growth.

After a note on the adsorption-processes (surface-tensions and other such fine-world forces), the author brings his argument around to the basic geometry of cell-aggregates, and it arrives, as it must arrive, at the tetrahedron, the fundamental unit of the regular convex polyhedra, and then branches out to the compromises cells must make in tissues, where the simple geometric packings of the early cleavage-stages are supplanted by vegetative and animal poles in the organism. Now we find ourselves in the presence of spicules of silica, and see how simple geometric forms are used, for example, by the Radiolaria, in which the space-geometry of crystals is sometimes imposed by the inorganic material itself, so that the simple geometry of the earlier cleavage-stages is extended to the whole span of life. The study of the regular polyhedra is short and incidental, and most of the remainder of the great work is devoted to the equiangular spiral, to leaf-arrangements, to the shapes of eggs, and to form as related to mechanical efficiency.

But we arrive at last at the point where all the preceding labour brings the rich reward of a glimpse of ideals behind the physical compromises: the Theory of Transformations. (1026) It is probably for this, as much as for any other single feature, that Sir D'Arcy's book has been read so closely for so long. Here he shews how a fish may be placed (diagrammatically) in simple Cartesian coördinates. Then the coördinates may be changed by certain simple deformations, discussed in the same chapter, carrying the fish-form along, part for part, point by point. And we observe that the fish-form resulting from such deformation, so far from being some weird or other figment of whimsical invention, turns out to be a known species; in the case of the porcupine-fish *Diodon* the hyperbolic deformation gives us the sunfish *Orthogoriscus mola*. Now, not only is this fish found in Nature, as we have pointed out, but it is closely related to its Cartesian counterpart. The space-transformations are wrung through no fewer than four frames of reference (1036 et seq.), beginning with



*Polyprion* in Cartesian, *Pseudopriacanthus altus* in triangular, and *Scorpaena* in radial, coördinates, and ending with a very curious fish, *Antigonia capros*, in a certain peculiar deformation.

It is significant that the rule of the idea behind these findings is best shewn in fish, for they are an old species and therefore give amply elaborated displays of evolutionary resource. Yet they are vertebrates, and so, well articulated. Furthermore, they are swimmers in the less gravity-governed waters, and so their symmetries are more freely achieved. Here, then, we can see the Idea at work, and the conclusion is irresistible: space-time has properties which living, growing, evolving creatures reveal.

A great vista of thought opens through this work. When this wondrous world of form and forces in life and matter, which Sir D'Arcy Thompson has made so much his own and has now shared with us more richly and anew, is treated in terms of the superior geometry of hyper-space available to us to-day, we shall surely be compelled to admit the supremacy of a latent harmonious order that holds all the world in fee. For mankind as a social complex this is the most important fact for us to face. *On Growth and Form* is, thus, far more than the finest collection of those facts which lead us to the threshold of a knowledge of Nature's abstract orders. It is one of the most challenging philosophical works of this century: we are in debt to author and publisher alike for a wealth of wisdom and of pictorial treatment of one of the noblest of themes: the inherent supremacy of order in Nature.

F.K.

ON GROWTH AND FORM, by D'Arcy Wentworth Thompson. A new edition, 1942. Cambridge: at the University Press. New York: The Macmillan Company. 1116 pages, 554 illustrations. \$12.50.

## Physical Constants

ATTENTION IS CALLED to Special Paper No. 36: "Handbook of Physical Constants," published on January 31, 1942 by the Geological Society of America. The 325-page volume, edited by Frances Birch, contains twenty-one parts prepared by nineteen specialists coöperating through the Divisions of Chemistry, Physics and Geology

of the National Research Council. Geological libraries have this handbook for consultation, and it may be obtained in paper cover for \$1.40 from The Geological Society of America at 419 West 117th Street in New York. (*Journal of Applied Physics*, 13, 687, November 1942. A.J.P.)



BIOCHEMISTRY AND MORPHOGENESIS is the most recent of books by a distinguished Cambridge biologist, best known for his great three-volume *Chemical Embryology*. Such being the status of Dr. Joseph Needham, F.R.S., he is known, with Britannic understatement, as a Reader in Biochemistry.

He writes Chinese. On the first free leaf of the present book he has written and translated into English "Mencius said: extensively learn and in all detail state it, so that later, summarise its essence." Below this we find, in ideographs, that "this book is dedicated to my friends Misses Li Ta-Fei and Lu Kwei-Ching. Joseph Li." Joseph Li is, indeed, at this moment on his way to China, where he — like others who already know the East a little — recognises the existence of a pool of wisdom, upon which earlier Western thinkers, in Ionian Greece, arose like iridescent bubbles.

By counter, here are 677 pages of that kind of close study which is distinctive to the modern intellectual ascetics, whose devotion to their own kind of knowledge rivals that of the oriental sage to his.

The trail runs along that narrow borderland where subtle chemical substances, called evocators, in quantities precisely right, appear in embryos and control the history of a living creature by a sort of biological boot-strap-lifting. What evokes the evocators? Is the answer to be found in China?

This is no impertinent question. The Chinese have a medicine, Ch'an su. It is made of dried toadskins and is used as a remedy for hæmorrhages. Will the western physician use dried toadskins as a medicine? Probably not. But when he has examined them he will find that they contain a powerful charge of adrenalin, a chemical which he himself has recently discovered as a drug for the control of hæmorrhage. If China has a realistic medicine after all, perhaps she also holds secret for us a likewise respectable knowledge of life, to balance our own. Hers is interwoven with animism, and this offends the captious modern intellect. Dr. Needham, however, is evidently well-armed to wrest the values from those of her beliefs which may be vain:

"Any who might be led to suppose that words such as 'inductor,' 'evocator,' etc., carry animistic undertones, would be under a complete misapprehension. They stand for definite chemical substances the nature of which is as yet not fully elucidated. They conceal no archæus or demon. In the use of the phrase 'oxidising agent' the chemist risks no confusion with 'passenger agent' and 'hydrogen-donators' head no subscription-lists. In this book, the word 'organiser' is always used to imply the presence of tissue, whether living or dead; 'evocator' refers only to a specific chemical substance; 'inductor' is a looser word available for both these senses." (xiv)

For present purposes, the most important development in biochemistry is Individuation Field, an electromagnetic field in the egg. (Or is the egg in the field? Perhaps this is our old friend which-came-first hen-or-egg? Only now the hen is of cosmic proportions and ovulation a space-time principle; in short, both are one.)

The evocator chemical exists in masked or inactivated form in all parts of the embryos except the organiser region. An egg may be conceived in theory to be pluripotent, so that it could develop into any variety of animal — a rabbit or a giraffe indifferently. But in fact the organiser and the evocator are operating upon inherited chromosomes, upon substances of ancient lineage, unaffected in most cases by the immediate parental individual experience. The inductors shut-off doors one by one, till the development is completed. Thus for millions of years trilobites and such can go on being themselves. What provides the unstable protoplasm with this incredible continuity, comparable in its own way to the regularity of the stars in their courses? The individuation field is part of the answer, and it brings us back to the present physical-science concept. We therefore cite the chief passages which bear on that fruitful notion, for the earnest philosopher will naturally feel impelled to read for himself at the source. It is important here to say that we are dealing with nerve-formation and hence with something that has correlations to the psyche.

"Evocation is the stimulus to neuralisation, mediated by a chemical host ectoderm . . . Individuation, on the other hand, is the process which builds the neural tissue so formed into a nervous system of which the head end is distinguishable from the tail end." (125)

"One region of the amphibian embryo, however, is much less plastic than the rest during the early part of development. This is the region of the dorsal lip of the blastospore, which has arisen from the grey crescent and will in time form the mesoderm, i.e. notochord, somites, etc. If a piece of this region is grafted into another embryo in the blastula or early gastrula stage, it will 'induce' the neighbouring host tissues to form a secondary embryo, often including nerve-tube, brain, eyes, ears, somites, notochord, etc., irrespective of the presumptive fates of those tissues. In other words, it contains within it the influence which determines the fates of regions with which it comes in contact. It is therefore called the *Organiser* (*Organisator* of Spemann). It is easy to demonstrate its fundamental importance in the development of the amphibian egg by separating the first two blastomeres instead of killing one of them, as in Roux's experiments. Their subsequent fate will now depend on whether or not they contain a sufficiency of the region which will afterwards become the organiser region. If both blastomeres contain a portion of it, both will be organised into small but morphologically normal embryos, in accordance with the original experiment of Driesch. If one contains all of it and the other contains none (as will happen if the first cleavage chances to be horizontal), the former will produce a complete embryo and the latter will give up the struggle, as it were, after a few cleavages. These effects were described by Hertzska as long ago as 1896, but the exact analysis of them awaited the beautiful constriction experiments of Spemann and Ruud & Spemann. A newt's egg constricted into two in the transverse plane will give from the dorsal

half a well-formed embryo and from the ventral half a blastula-like ball of yolk-cells developing no further ('Bauchstück'). But if it is constricted so as to separate lateral halves, it will give two perfect half-size embryos. Schmidt has shown that the same is true for the frog. On the other hand, fusion of two amphibian eggs into one is possible; it was accomplished by O. Mangold & Seidel. The organisation centres may fuse and produce a single neural axis on a giant embryo." (103)

"The notion of the Individuation Field had previously arisen from the experiments of Waddington & Schmidt, in which induction of the primitive streak in birds by heteroplastic grafts had been studied . . . It was found that an isolated organiser tends to rearrange its structure so as to include all regions of the embryo. Thus, 'an organiser whose presumptive fate was to become the mesodermal part of the middle region of an embryo may rearrange itself so as to become the mesodermal part of a whole embryo . . . An organiser tends to rearrange the regional structure both of itself and of any tissue lying near it in such a way as to make that tissue part of a complete embryo. This is then a true unit-building activity of the organiser, which works, not by controlling the process of induction, but by modifying its products.' The activities of the organisation-centre could thus be stated as follows. There are, on one hand, more or less autonomous processes of induction of neural plate, etc. (Evocation) by which the organiser can prepare from its surroundings all the types of tissue necessary for the formation of a complete embryo. These processes are not under the direct control of a unit-building force, as can be seen by the occurrence of homoigenetic induction. But in point of fact the amounts of the various sorts of tissue which are normally formed by these processes just suffice for the production of one embryo. Meanwhile a process of a different type, which is expressed in the individuation field, is in control of the regional character of these tissues, and attempts to build them into one complete unit. Waddington & Schmidt described the individuation field as follows: (1) it is strongest near the embryonic axis and falls off in intensity towards the edge of the area pellucida, (2) it is regionally differentiated along the antero-posterior axis of the embryo, (3) more anterior parts dominate over more posterior parts." (126)

"The conviction that the magnetic field has a part to play in guiding our ideas about morphological patterns is now of some seniority. I pointed out earlier that it fulfills the criterion of divisibility of pattern which is needed for embryology (p. 120). Now if an analogy is a true one, the course of scientific thought will be greatly facilitated; thus Wrinch has referred to the fundamental progress in electrostatics and current-electricity due to Clerk-Maxwell's genius in seeing formal resemblances between conditions to be satisfied in already solved problems belonging to other subjects. The masterly apparatus developed by Laplace and Poisson in the treatment of elasticity became available in this way for



Sea-urchin egg in early cleavage-stages, to shew especially head (animal) and tail (vegetal) ends: fourth figure from left. (From Needham)

electrical theory. Can we then obtain knowledge of biological phenomena by means of our knowledge of magnetic phenomena? In other words, is there an identity of formal characters in the two cases? Many, especially in recent times, have thought so, notably Weiss; Gurwitsch; and Rudy. Schultz has caustically remarked that fields without centres, without measurable field strengths, and with no obvious lines of force, cannot invite comparison with the fields of physics. But this criticism is hardly justified, for in William Gilbert's time (A.D. 1600) certain phenomena of magnetic fields were known although no method was available for measuring field strength. The concept of 'biological field' does give a powerful aid to the codification of the *Gestaltungsgesetze*, the rules of morphogenetic order. As complex components (in Roux's phrase) they must first be ordered before they can be analysed." (127-8) (Mr. Needham observes in the footnote to the closing sentence of the above paragraph: "It should be noted that there is an intimate relation between the field concept and the theory of transformations of D'Arcy Thompson . . . That particles do tend to orient themselves on progressively distorted coördinates is one of the most essential facts expressed by the term 'field'. . .")

"For Gurwitsch in the main the fields are geometrical symbolism, yet from time to time he speaks of their having an action or an influence. For Weiss the fields are more active . . . A similar position is taken by Waddington . . . The 'Individuation Field' is the term expressing the tendency of an organiser to rearrange the regional structure both of itself and of any tissue lying near it in such a way as to make that tissue part of a complete embryo . . . But the amount of thought which has so far been devoted to the concepts of field and gradient [radiating from centres and forming fields] is hardly yet sufficient to enable them to bear the load of facts which is often placed upon them." (128)

Thus we see another important junction effected between two whole great departments of modern thought: electrophysics and biology. And we see once again that the effective union, by means of the electromagnetic individuation field, involves the physical basis of the psyche — the process being that which differentiates the head end from the tail end of the creature, and being that which governs the nerve-development, which is (once more) the physical basis of the psychic goings-on. Surely it is impossible to resist this piling up of evidence that both life and energy, and consciousness therefore no less, have their roots in the common ground of the space-time matrix? G.L.

BIOCHEMISTRY AND MORPHOGENESIS, by Joseph Needham. Cambridge: at The University Press; New York: The Macmillan Company, 1942. xvi + 787 pages, 328 illustrations, \$12.50.

## THE COHERENT WORLD-MATRIX

DR. GUSTAF STRÖMBERG has written an article of first importance to philosophers in the October 1942 issue of *Philosophy of Science* (Volume 9, number 4). Dr. Strömberg, who is physicist at the Carnegie Institution of Washington, Mount Wilson Observatory, has made the relation of the phenomenal physical world to the noumenal space-time world a special interest. The article, on *Coherence in the Physical World*, should be consulted in its entirety, but Dr. Strömberg has given us his kind permission to cite here certain passages which have immediate bearing on previous discussion in our present pages:

The integrity of the cosmos is well established, for "there seems to be no inherent loss in coherence during the many millions of years it takes light to travel from a distant extragalactic nebula to the earth, although there is, of course, a loss in intensity due to the scatter of interstellar atoms. If the red shift in the spectra of the extragalactic nebulae, as now appears probable, is not due to outward motion, it may well be that it is due to a certain kind of energy dissipation. This dissipation does not affect the coherence of the probability structure, but the general time scale of this pattern and therefore of the individual photons. Zwicky has suggested that this 'grinding of the photons' is due to the effect of the non-uniform gravitational fields of the stars.

"Coherence can be expressed as an invariant quality independent of the motion of the observer. The large expanding probability patterns, when expressed in terms of space-time intervals, shrink to small size, and they would, if they had no structure at all, become points with no extension. The emergence is then not of varying amounts of energy and momentum, but of constant amounts of action. When pictured in such general terms, the appearance or disappearance of probability patterns becomes less difficult to understand. In such a picture the emitting and absorbing atom are in 'contact,' and the point of coincidence is the centre of a structure in space-time. Such a coincidence can take place only when the emitting and the absorbing atoms have certain structural elements in common, and what we call a light-beam is our anthropocentric description of the shared structural elements.

"When we speak of the a-causal emergence of photons carrying energy and momentum, the idea comes naturally to us that there is a realm from which they emerge and into which they again submerge. In other words, we may imagine a world beyond the space-time world with which alone physics is concerned. This world I have called the *non-physical* world, and all the well known phenomena, e.g., colour-sensations, which cannot be expressed in terms of space and time, belong to this world. I have shown the necessity of postulating such a world when we try to explain the organisation in the living world and the relationship between mind and matter. The photons belong to a particular class of elements intermediate between the physical and the non-physical world. These *intermediate elements* play a very important rôle in nature, and are responsible for the interaction between physical and non-physical phe-

## Life and Space-Time

nomena (*Scientific Monthly*, 54, 71, 1942). Their emergence is governed by coherent probability patterns, which in many cases can be well determined. As with photons, there is a close correspondence between the meshes in the probability pattern and the emergent elements...

"Coherence is a characteristic of all kinds of matter, although the size of the coherent systems varies greatly. The coherence of inorganic matter is especially marked in crystals. The atomic nuclei are here arranged in well-defined space patterns. The separation between the nuclei varies in different directions and depends primarily on the nature of the nuclei themselves. In other words, we assign certain physical properties to the nuclei on the basis of the structure of the fields associated with the nuclei. It is obvious that the structure of a coherent crystal can be described as a field of 'force' in which a fundamental space-time pattern is reiterated. The great strength of the bonds that hold the system together is very significant. It seems that the atomic nuclei are confined to definite cells in a structure which in some way is related to the nuclei, but itself is built of a 'stuff' of another type. Just as in the case of electron beams, we assign energy, momentum, and inertia to the particles themselves, whereas the coherence is regarded as a property of the framework in which the particles make their appearance.

"When a crystal is struck, the field oscillates as a coherent unit, in itself a strong indication that the field is 'loaded down' with particles rather than produced by them. The elastic waves travel with different but definite speeds in different directions. The interaction between the field in the crystal and an incident radiation gives rise to polarisation effects. Crystals can easily be split along certain cleavage planes. When a crystal is subjected to a very high, uniform pressure, it is usually not much deformed, but the regular layers of nuclei may collapse, one layer after another, like the storeys of a collapsing building...

"In living organisms a particular type of coherence in space as well as in time is clearly evident. The coherence in space is often called *organisation*, and the coherence in time is often described as a *development* towards a well-defined, predetermined structure. The highly co-ordinated structures, so clearly manifested in the higher animals, cannot be the result of the electrical fields in the atoms and molecules and chemical substances of which the animal is built. A *coherent guiding field* of highly specialised properties must be postulated to account for the structural and functional characteristics of the animal. In the embryonic development of a number of animals, Hans Spemann (*Embryonic Development and Induction*, C. xv, Yale University Press, 1938) has shown the necessity of assuming the existence of a 'field of organisation,' which spreads from a definite point in the embryo and induces the formation of nerve tissue and the rudiments of the highly organised nervous system. A very simple case of the effects of a 'living field' is offered by the transformation of a blastula into a gastrula, which occurs in the embryonic development



of most animals, a transformation which in a very striking way shows the highly coördinated effects of a guiding field extending over the whole embryo. Such fields can in no way be explained by forces originating in the matter of which the embryo is built or by forces emanating from the individual cells.

"A living field differs from the fields or probability patterns we have previously described in several important aspects. A living field can change its space scale from an infinitesimal size in the ovum or in the embryo to the large scale in the fully developed animal. It can also completely disappear, and this is what happens at death. Some of the living fields determine the structure of an individual cell, others the structure and functions of an organ. The more general organising field in a vertebrate is observed visually as an enormously complicated system of stable, interconnected neurones in the brain and its extension in the spinal cord and the central nervous system. Nobody would probably object to the statement that the nervous system in the higher animals represents the physical aspect of a highly coördinated and therefore coherent entity. For the more complex coherent living fields and their sources I have suggested the term *genii*, but the name itself is not of great importance.

"When a living field is in a highly contracted or potential form in the egg-cell, we can well imagine it to have hardly any space-extension at all. It is nothing but a source, capable under certain conditions of producing a guiding field with a definite structure. A 'living source' has probably no rest-mass at all, and in its contracted form it has then no energy content. It differs therefore from the elements of matter which are *sources of observable energy of definite amounts* and serve as *indicators of a field structure*. To have any physical effect on matter, that is, on an electromagnetic structure, a contracted living source must first expand, that is, develop its field, until its space scale becomes of the same order of magnitude as that in the molecules having a frequency pattern similar to the potential space-time pattern of the living field, the living and the non-living

frequency patterns, which are the same as energy patterns, have a tendency towards equalisation. The atoms fall into the energy minima of the living fields and are captured, provided they move slowly enough, have the right structure, and can quickly get rid of certain energy amounts by radiation or otherwise. The expansion of the living fields requires energy, and this is ordinarily taken from certain chemical substances. These substances are called *hormones*, and some of them are, so far as their effects are concerned, identical with what the biologists call *organisers*. In nature they are usually formed by resonance effects, although most molecules thus formed are not stable in the absence of the living field. Ions of oxygen seem to act as a hormone of a very general type and probably initiate the development of the living sources in an embryo.

"Living sources are elements intermediate between the physical and the non-physical world, as I have described in my Scientific Monthly article . . . [summarised in MAIN CURRENTS, volume II, number 3, pp. 4-5 (January 1942)]. Like particles, they are emergent entities, but their emergence is of long duration and is represented by the life time of the living elements. They have a physical aspect expressible in terms of the space-time structure of their associated fields, and they have also a non-physical aspect, which is manifested in many ways, particularly as a purposeful development and, for certain nerve-cells, as phenomena in our consciousness . . .

"The whole material universe can be regarded as a *coherent field on a cosmic scale*. The term *material* is here used to emphasize that there is a close connection between the distribution and the amount of matter, on one hand, and the space-time properties of the universe, on the other. That such a connection exists was first shown by Einstein to be a consequence of the general theory of relativity. Many would claim that matter is the cause of the field properties. But our ordinary ideas about cause and effect are not applicable to this case, because we cannot annihilate matter and study the consequences, at least not on a scale large enough to affect the general properties of space-time."

## RECENT ITEMS

### Wolf-Girl

IN MAIN CURRENTS, April 1941, page 5, we made brief reference to the first authentic case, among some thirty-five records, of a "wolf-child", Kamala. It is now fully reported in *The Diary of the Wolf-Children of Midnapore*, by J. A. L. Singh and *Feral Man and Cases of Extreme Isolation of Individuals*, by Robert M. Zingg, Ph.D. (IV. Contributions of the University of Denver. Harper & Brothers, 1942).

The case of Kamala is about as decisive as it can be in shewing that association with collective humankind is powerful, and not indifferent, as a factor for the child's maturing. Common sense has always held this to be obvious, but common sense is not always a safe guide and not all scientific opinion is common sense. Kamala spent her infancy abandoned among wolves, and was rescued by the Reverend J. A. L. Singh of the Midnapore Orphanage.

She had to be weaned from her wolf-ways. At first, she crouched in a corner, disliking companionship. She preferred night to day, and raw food to cooked. She lapped her gruel on all fours and growled. Gradually she succumbed to the socialising impacts of the daily life of the orphanage. In 1921, she showed her teeth when children came near her; in 1922, she walked on her knees; in 1923, she stood alone on both feet; in 1924, she spoke her first spontaneous word; in 1925, she drank from a cup; by 1926, she had a vocabulary of some thirty words; in 1927, she went on simple errands and helped to mind the babies; in 1928, she could speak in short phrases and sentences; in 1929, unfortunately for science, she died from uræmia; and "thus ended a life in our Orphanage, and there ended my study of her." But what had brought her over to humanity? It was Mrs. Singh's loving patience, the impact of humankind in every one

of that million-or-two of minutes, which overcame the wholly disadvantageous start for the organism. But the study of the finest known instance of feral man came to an end before certain punctual questions could be raised and answered. The main issue was, however, settled. The organism does not cause characteristics special to humanity to appear in the personality. It is only their vehicle. Neither does deprivation of human companionship destroy the organism's power of mutual response to human social influence. Human living is a highly specialised evocator in environment. Almost we may therefore speak of a *psychic climate*. G.L.

## A Migration of Mathematicians

THE AMERICAN MATHEMATICAL MONTHLY (August-September 1942) tells us that "one of the greatest migrations of mathematicians in history has taken place in the past few years. In the ten years from 1933 to 1942 inclusive, at least 131 notable mathematicians have left their homes in Europe and have become residents, and many of them citizens, of the United States. According to Arnold Dresden there are many whose fame preceded them — for example Albert Einstein, Wolfgang Pauli and Jacques Hadamard. Of these 131 mathematicians, 16 came from Göttingen, 7 from Prague, 6 from Zürich, and 4 from Warsaw. The special fields of a considerable fraction of these recent arrivals in America are theoretical physics, statistics, actuarial statistics, engineering and astronomy. The rapid assimilation of these foreign scholars in time of a depression and declining resources for the support of universities is due both to their fine adaptability and to the cordial welcome that their colleagues in this country have extended to them." A.J.P.

## A Dual Time-Scale

DR. LEOPOLD INFELD of the School of Practical Science, University of Toronto, draws attention to *Time and the Universe: A New Basis for Cosmology*, by F. L. Arnot. This book was published in 1941 by the Australasian Medical Publishing Company, Ltd., in Sydney, after the premature death of the author. In the Review of Scientific Instruments (October 1942), Dr. Infeld tells us that "it is more like a long scientific paper than a book, and contains mostly original results. Its subject is related to the works of Milne, Eddington and Dirac.

"The principal idea . . . is the introduction of two different time-scales: the *r* scale and the *t* scale.

"In the *r* scale, the velocity of light is assumed to be constant; in the *t* scale, the frequency of the emitting atom is assumed to be constant. The most obvious assumption, that these two time-scales are identical, is abandoned, and the relation  $r = t_0 \log(t/t_0) + t_0$  is introduced instead. Here  $t_0$  is the present moment of the universe in the *t* scale. Thus the *r* scale ranges from  $-\infty$  to  $+\infty$ , whereas the *t* scale ranges from 0 to  $\infty$ , with 0 as the moment of creation of the universe. In this way the author reconciles the two possible views, expressed in Eddington's *The Nature of the Physical World*: ' . . . the difficulty of an infinite past is appalling. It is inconceivable that we are heirs of an infinite time of preparation; it is not less inconceivable that there was a moment with no moment preceding it.' From this

assumption of two time-scales some seemingly strange conclusions can be drawn: that the number of elementary particles changes in the *t* scale but not in the *r* scale; that the velocity of light changes in the *t* scale but remains constant in the *r* scale. But this theory is not purely speculative: it explains the phenomenon of the red shift of nebular spectra and shows the age of the universe to be  $2 \times 10^9$  years.

"The principles of cosmology, mechanics and quantum-mechanics are viewed from this point of view of a dual time-scale. The assumptions are clearly formulated and the arguments are lucid.

"The work on cosmology of Milne, Eddington and Dirac is viewed skeptically by many physicists. Some see in it a repulsive abundance of pure speculation. I must admit that I shared the view of these physicists and that this small book has very much weakened my skepticism. The author presents his case with forceful simplicity and consistency. It would be good if an abbreviated version of this book could find its way into a scientific journal. Otherwise this book, published far away and probably in a very limited edition, may not find the readers it deserves." A.J.P.

## Thermal Earth-Shell

ON ACCOUNT of its practical inaccessibility, that region of the earth's atmosphere which lies between 35 and 60 miles above sea level cannot be studied for its temperatures and densities except through the use of observations of meteors. According to Frederick L. Whipple of the Harvard University Observatory, new observational data is in good agreement with previous suggestions that the atmosphere is hot (just under the boiling-point of water) in a narrow zone about 40 miles above sea-level. (Reviews of Modern Physics, 14, 139. April-July, 1942. A.J.P.)

## Six Psychic Types

AN ARTICLE ON *Monotony: Its Analysis and Theory*, by H. Quednau, reviewed from *Industrielle Psychotechnik* (1940, 17, 84-100) by *Psychological Abstracts* in its November 1942 issue, describes the results of tests made with Giese's monotony-meter on Hollerith machine-operators.

The worker's attitude toward, and his interest in his work were found to be of greatest importance. Five definitive worker-types were discerned: Type 1 suffers from monotony because he cannot interest himself in any repetitive task. Type 2, however, can resist the feeling of monotony when the task is his vocation. Type 3 enjoys monotonous work by making a game of the operations. Type 4 is the day-dreamer, who can dissociate himself from the task and thus not suffer from its monotony. Type 5 is too dull to suffer from monotony. "The core of the problem is the relation of the worker's aspiration regarding the interestingness of his vocation to the inherent interestingness of his work."

Classifications along this line may be of increasing importance in the future. Where men make thousands of machine-parts in preassembly-work and are thus deprived of the achievement-satisfaction of seeing the whole take shape under their hands, monotony is clearly

a considerable factor as it affects those who perform mechanical and unvarying tasks. An examination of the worker's personality-characteristics will, in an enlightened future, have a prominent place in his aptitude-test.

The present writer feels that a sixth type might well be added to the list: the thinker-dreamer, who is the antithesis of the day-dreamer in that the thoughts of the latter dissipate futilely in all directions, whereas the thoughts of the thinker-dreamer converge to a point and are thus helped to do so, instead of being hindered from doing so, by the monotony of mechanical work to

be done with a minimum of will- and mind-energy.

The present emphasis in popular education in the United States is upon mechanical aptitude, "work with the hands," such as is employed in the educational system of Soviet Russia, of Madame Montessori and many other educators. The transcendent value of doing such work-with-the-hands is well instanced in the case of Spinoza, who worked contentedly and abstractedly grinding and polishing lenses, while his mind, freed by the quiescence of his body and by placidity of feeling, was able to leap forward to explore new fields of thought and concentrate its energies upon discovery. A.H.P.

## AMERICANS OLD AND NEW

Dr. Franz Boas

THE PASSING OF DR. FRANZ BOAS ON December 21, 1942, offers us a fitting occasion to recall certain interesting contributions from the mighty edifice of that great anthropologist's life work. Dr. Boas had many interests. He wrote with authority on the life and culture of the American-Indian, the esoteric teaching in American tribal groups, the so-called kiva Masonry. In his last voluminous book, *Race, Language and Culture*, published in 1940 by The Macmillan Company, is a chapter titled *The Ethnological Significance of Esoteric Doctrines*, from which we quote:

"The symbolic significance of complex rites, and the philosophic views of nature which they reveal, have come to us (ethnologists) as a surprise. . . .

"It seems worth while to consider the conditions under which these esoteric doctrines may have developed. Two theories regarding their origin suggest themselves: the esoteric doctrine may have originated among a select group, and the exoteric doctrine may represent that part of it that leaked out and became known, or was made known to the rest of the community; but it may also be that the esoteric doctrine developed among a select group from the current beliefs of the tribe. It seems to me that the second theory is the more plausible one, principally for the reason that the contents of the teachings among different tribes are often alike, no matter how much the system may differ. Almost all the rituals that are outward expression of esoteric doctrines appear to be old, and many have probably existed, almost in their present form, for considerable periods. Nevertheless there is ample evidence of borrowing and changes of sacred rites.

"Since the esoteric teaching refers to the rituals, and is often largely based on mythological concepts, it seems plausible that it should have developed as a more or less conscious attempt at systematizing the heterogeneous mass of beliefs and practices current in the tribe. Whenever a certain ceremonial came to be placed in charge of a small social group, whether of chiefs, of priests or simply of men of influence, the conditions must have been favourable for the development of an esoteric doctrine. The thought of the men charged with the keeping of sacred rites must have dwelt on philosophical or religious questions, and it

would seem natural that in the succession of generations the sacredness increased in depth.

"If this view is correct, the esoteric doctrine must have been evolved on the foundation of the general culture of the tribe, and must be considered as a secondary phenomenon, the character of which depends upon the exoteric doctrine.

"The opposite view, that the exoteric doctrine is a degenerate form of esoteric teaching, does not seem to me equally plausible, because it presupposes a highly complex system of actions and opinions originating spontaneously in a selected group of individuals. It is difficult to conceive how, in tribal society, conditions could have prevailed that would make such a development possible. This theory would seem to presuppose the occurrence of a general decay of culture. There is no reason that compels us to assume that such a decay has taken place although it may have occurred in exceptional cases."

Must we, as Dr. Boas suggests, choose between two processes? Can there not be a two-way action between esoteric and exoteric? No doubt a more or less complex system, originating spontaneously, must be inferred if exoteric beliefs are assumed to have degenerated from esoteric teaching. The history of the world's religions, however, offers no obstacle to this belief. On the contrary, it supports the view. The Christian religion offers one of the best examples: The early Christian Fathers—Clement and Origen among them—were evidently in possession of an esoteric doctrine which, it may be assumed, comprised the (spontaneous) teachings of Jesus. The New Testament amply corroborates the existence of a secret teaching:

And when he was alone, they that were about him with the twelve asked of him the parable. And he said unto them: Unto you it is given to know the mystery of the kingdom of God: but unto them that are without, all these things are done in parables. (The Gospel According to St. Mark, IV:10,11)

And with many such parables spake he the word unto them, as they were able to hear it. But without a parable spake he not unto them: and when they were alone, he expounded all things to his disciples. (Ibid., IV:33,34)

Give not that which is holy to the dogs, neither cast ye your pearls before swine. . . . (Matthew, VII:6)



Dr. Boas has a second objection to the idea that exoteric belief is simply that part of the esoteric doctrine that has leaked out: Such leakage, says he, presupposes the occurrence of a general decay of culture.

But does not history bear this out? The case of Greece is well known. Egypt might be a still better example than Greece, for the culture of Egypt appears to have been well on the decline even from the moment of our recorded history of that great civilization of the Nile. History always points to Time as the great perverter of teachings and doctrines. As they pass through divers hands, especially when transmitted orally, that they should lose in depth and meaning is inevitable.

The discovery of an esoteric teaching in the American tribal societies should occasion no astonishment among ethnologists. Why should these secret doctrines be viewed in a light altogether different from that in which the doctrines of nations in other parts of the world are viewed—let us say, of India, China or Persia? Is it because no particular messiah or religious teacher has been traced or attached to American-Indian doctrines? The names are missing. Cannot such beings be assumed to have existed? Does there not seem to be a certain pattern of inspiration within nearly all religious teachings the world over? Is it not likely then that the American-Indians, too, had their Zoroaster, their Buddha, their Christ, their Laotse, their Krishna? If so, here is the spontaneous force and source of the complex systemization which is bequeathed to us—now, indeed, no longer in its pristine purity, but still lofty enough to tower far above the exoteric beliefs of to-day.

Perhaps Boas will finally be best remembered for the statistical study he made of the head-measurements of the Europe-born children of American immigrants and of their America-born siblings.

As a memorial to Dr. Boas it is fitting that we should recite the essential facts which we were prompted to report in *Main Currents*, July 1941, pages 1 and 2, by a book-review in the May 31, 1941 issue of *Nature* (page 656). Here Sir Arthur Keith reviews two important works by Professor E. A. Hooton: *Crime and the Man*, and *The American Criminal* (Harvard University Press, 1939). The reviewer accepts the proposals, which Dr. Boas had made thirty years earlier, that a tendency toward new race-type has appeared in North America. That so many years had to pass before this advance in thought found general acceptance shews only the more forcibly how revolutionary Dr. Boas' discovery was.

The New American is to be contrasted with the Old American stock, investigated by Dr. Aleš Hrdlička of the Smithsonian Institution, and is a phenomenon in the new immigrant strains, which progress very rapidly, in head changes and in other characteristic changes, toward an American norm.

"Another of the side-line inquiries [Sir Arthur writes] relates to the process of 'Americanisation,' namely that children of immigrants, born in the United States, undergo not only a cultural but also a transformation of body in the land of adoption. There are many besides the reviewer, who viewed with scepticism the claims made by Professor Franz Boas that children born of Italian parents in America differ in head form and

in many other statistical details from the original Italian stock. Scepticism is no longer possible, for Professor Hooton's statistical inquiries confirm those of Professor Boas. . . . With such inquiries it is pertinent to compare those made by Dr. H. L. Shapiro on Japanese born in Hawaii. This observer found that the Hawaiian Japanese differed statistically from the immigrant Japanese and these, in turn, differed from the folk in Japan from which they had been drawn. How we are to explain such environmental transformations I do not know, but it is plain that all three of Dr. Shapiro's groups remained unmistakably Japanese" although their cranial index approached the American norm.

The findings of Dr. Boas himself are, in effect, best summarised by him in *The Mind of Primitive Man*, page 53, where he says: "It has been my good fortune to be able to demonstrate the existence of a direct influence of environment upon the bodily form of man by a comparison of immigrants born in Europe and their descendants born in New York. I have investigated four groups of people—the South Italians . . . the Central European type . . . the Northwest European type and an extended series of East European Hebrews. . . . The traits I have selected for examination are head measurement, stature, weight and hair colour.

"The results of our inquiry have led to the unexpected result that the American-born descendants of these types differ from their parents; and that these differences persist throughout life. It is furthermore remarkable that each type changes in a peculiar way."

1. Head of America-born Sicilian becomes rounder than that of the foreign-born. Face becomes narrower; stature and weight decrease.
2. Head of America-born Central European loses in length and width, more so in width and thus becomes elongated. Face decreases much in width; stature and weight increase.
3. America-born Hebrew:
  - a. Head longer and narrower, much elongated therefore.
  - b. Face narrower.
  - c. Stature and weight increased.

"Investigation of Hebrews shows very clearly that the cephalic index of foreign-born is practically the same, no matter how old the individual at the time of his immigration. This might be expected when the immigrants are adults or nearly mature; but it is of interest to note that even children who come here when one year or a few years old develop the cephalic index characteristic of the foreign-born. . . . The effect of American environment makes itself felt immediately [i.e., on children born in America, of course] and increases slowly with the increase of time elapsing between the immigration of the parents and the birth of the child.

"The conditions among the Sicilians and Neapolitans are quite similar to those observed among the Hebrews. The cephalic index of the foreign-born remains throughout on almost the same level. Those born in America immediately after the arrival of their parents show an increase of the cephalic index. In this case, the transition, although rapid, is not quite so sudden as it is



Shewing (1) the average form of the head of the foreign-born Hebrew; (2) the average form of the head of the foreign-born Sicilian; (3) the average form of the America-born Hebrew and Sicilian born more than ten years after the arrival of the mother in America. These sketches are intended only to give an impression of the change in proportions. They do not represent the head-forms in detail.

among the Hebrews, probably because among those born a year before or after immigration there is some doubt as to the place of their birth."

The original epochal paper by Boas constitutes Document No. 208, Second Session, 61st Congress, 1911. We quote from it:

"We are compelled to conclude that when these features of the body change, the whole bodily and mental make-up of the immigrant may change. . . . From these facts we must conclude that the fundamental traits of the mind, which are closely related with the physical condition of the body and whose development continues over many years after physical growth has ceased, are the more subject to far-reaching changes. It is true that this is a conclusion by inference, but if we have succeeded in proving changes in the form of the body, the burden of proof will rest on those who, notwithstanding those changes, continue to claim the absolute permanence of other forms and functions of the body."

Since foremost anthropologists are satisfied as to the reality of a new race-type in America, serious and practical questions arise. First we may wonder about the specific forces which bring such a phenomenon about. Is there an *Ortgeist* as well as a *Zeitgeist*? And we may well have doubts concerning the suitability of the whole educational process in America, where

schooling is postulated upon a caricature of the intellectual training of Europeans. One is entitled to question that the new American is at bottom an intellectual race. Thus, in effect, by making people literate, we also render them exploitable through their ability to read (propaganda, advertising) though our intentions were cultural. Meanwhile do we not ignore education of the emotions, and thus stunt and frustrate the intuitions? If so, we may be producing a race of glorified "Connecticut Yankees" (the epithet has no geographical implications!), skilled in invention or alternatively people not inventors, who rise up to be masters of sharp practice in business; instead of accelerating the appearance and supremacy of a people of well-developed emotions and capable of far-reaching artistic and true philosophical genius, which alone may flourish out of a rich and sound intuition. The American "hunch" could come to be something if the educational system facilitated its appearance. Much of life is suprarational. Many thinkers easily envision a new race thousands of years hence. It is more difficult to admit the appearance here and now of the beginnings of such a race, and to do something to detect its special features that we may meet its conspicuous needs. Among those conspicuous needs is an economic system created by our country against a background of natural law, to supplant slowly the patchwork we have inherited. H.F.

## Theatre of Plant Life

THE CAREFUL ASSEMBLING of a bibliography of standard, recent and interesting texts is part of the program of Main Currents. One requirement in this department is that books shall be bountifully illustrated, so that the reader may enter into experience of the most diverse and newest fields by the delight of eye. Another is that all parts of the subject be discussed in the volume. The glossary should be at least adequate, and the text not so technically and austere specialised as to impede the reader of liberal education in following the argument.

PLANT BIOLOGY, by Paul Weatherwax. Philadelphia and London: W. B. Saunders Company, 1942. 455 pages with 417 illustrations on 182 figures. \$3.25.

## Book Notice

Dr. Paul Weatherwax, who is professor of Botany at Indiana University, has just issued a beautiful volume on *Plant Biology*. It fills our bill in practically each respect. The drawn and photographed materials are remarkably fine in this work, and the account of the subject is simple and straightforward, so that for anyone who is at last aroused to make an attempt to understand plant life as part of the great scene around him we have here an exceptionally well-wrought volume that can be read with uninterrupted pleasure as a preparation for any later special reading in this field.

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